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WOODLAND PONDS AS AN IMPORTANT HABITAT OF *Hippeutis complanatus* (Linnaeus 1758) OCCURRENCE - EFFECT OF ENVIRONMENTAL FACTORS AND HABITAT PREFERENCES

ANETA SPYRA

Department of Hydrobiology, Faculty of Biology and Environmental Protection University of Silesia, Bankowa 9, 40-007 Katowice, Poland; e-mail: aneta.spyra@us.edu.pl

Abstract

Spyra A.: Woodland ponds as an important habitat of *Hippeutis complanatus* (Linnaeus 1758) occurrence – effect of environmental factors and habitat preferences. Ekológia (Bratislava), Vol. 33, No. 2, p. 101–115, 2014.

In industrial areas, woodland ponds are refuges of biological diversity. The impact of environmental factors such as the physico-chemical properties of water, organic matter content in bottom sediments and various types of substratum on the occurrence of *Hippeutis complanatus* were assessed. In Poland, it is considered to be a species with an established but unspecified risk, deserving the status of endangered species due to the decline of wetland environments. A Canonical Correspondence Analysis (CCA) revealed associations between the distribution patterns of freshwater snails species and the concentration of nitrates (NO_3) and calcium (Ca) as well as pH and the organic matter content in the bottom sediments. Based on statistical relationships, results of study suggest that the kind of substratum (*Typha latifolia* remains, *Phragmites australis* remains, fallen leaves of waterside trees) has an impact on the occurrence of freshwater snails including *Hippeutis complanatus* for which the preferred substratum is the fallen leaves of waterside trees and sites with a high content of organic matter in bottom sediments. The study has shown that isolated water bodies located in forest complexes can be refuges for species that occur in small numbers in other types of aquatic environments.

Key words: Planorbid snails, freshwater snails, rare species, temporary ponds.

Introduction

Freshwater Planorbid snails inhabit different ecosystems of stagnant and flowing waters. This group includes many species, both common and frequently occurring as well as rare species in a specified area. The habitat preferences of some like *Hippeutis complanatus* (Linnaeus, 1758) are poorly known even though its occurrence has been documented in literature. It occurs in standing waters overgrown with plants (Merkel, 1894; Boycott, 1936; Kerney,1999) as well as in flowing waters with a low rate of water flow. It has been found in fish ponds (Beran, 2002; Strzelec, 1993a) and other anthropogenic reservoirs, particularly those with no outflow (Lewin, Smoliński, 2006) as well as in oxbow lakes (Żadin, 1952). It is less common in the canals and slow-flowing streams and rivers (Kerney, 1999; Glöer, Diercking, 2009). In Hamburg, it is most common in well-vegetated ditches (45% of 399 sampling sites) (Glöer, Diercking, 2009). It inhabits lakes of different sizes and trophic levels including, among others, dystrophic environments (Aho, 1966) as well as bogmoors (Baba, 1991). It is found in water bodies surrounded by fields and deciduous forests (Økland, 1990).

In different aquatic environments, *H. complanatus* inhabits a variety of substrates, mostly submerged macrophytes and muddy bottoms**.** In habitats without vegetation, this species lives on stones. It is generally regarded as a species intolerant of water level fluctuations, leading to periodic desiccation of water bodies, and which avoids ephemeral environments (Hubendick, 1947; Piechocki, 1979; Kerney, 1999).

H. complanatus is a palearctic species. Its range includes north-west Africa and western Mediterranean countries, and the entire area of Europe to the Yenisei and Ob in Siberia. To the south, its range reaches Caucasian countries and in the north to Scandinavia.

Location of woodland ponds in forest complexes results in their isolation from other aquatic environments; they are habitats of rare, legally protected or endangered species of plants and animals, as well as those that are not found in other habitats (Gibbs, 1993; Collinson et al., 1995; Nicolet et al., 2004). The biology and ecology of this species being poorly known, there is very little data on the impact of various environmental factors on its occurrence in the literature. Some authors consider it to be a ubiquitous species appearing in low densities (Piechocki, 1979; Cioboiu (www.oen-iad.org/conference/docs/6-invertebrates/ciobou.pdf), while others (Merkel, 1894; Zeissler 1987; Strzelec, 1993a) indicate it to be a rare species that occurs in scattered sites. In Poland, it is considered to be a species with an identified but not defined threat. The drainage of wetlands and riverside meadows, pollution and eutrophication have led to a decline in the distribution of gastropod species, including *H. complanatus*. Due to the loss of wetland environments, it should be identified as an endangered species (Głowaciński, Nowacki, 2005). In Hungary, it belongs to common species (Feher et al., 2004).

Owing to the presence of only a few types of substrates in woodland ponds, the study is aimed at verifying the hypothesis that the occurrence of *H. complanatus* will be differentiated and at determining the effect of different types of substrate which are available in woodland ponds on *H. complanatus* occurrence. The surroundings with deciduous forest results in an accumulation of tree leaves on the bottom. Leaf deposits are characteristic and sometimes the only substrate for the occurrence of snails. For this reason, in this research, one site in leaf deposits in each pond was selected to answer the question of whether it can be the preferred substratum for this species.

A characteristic feature of woodland ponds is high organic matter content in bottom sediments. It was assumed that if the woodland ponds are the preferred environments for this species, the organic matter will have an impact on its occurrence. Also, the influence of selected physical and chemical water parameters on the occurrence of *H. complanatus* in relation to snail communities in woodland water bodies was determined.

Material and methods

Study sites

The study was carried out in the three anthropogenic water bodies located in forest complexes in Upper Silesia (Southern Poland) (Fig. 1). These water bodies are all used in fish pond management, and one is also a storage reservoir (pond 3). They have different areas, depths and sediment types (Table 1) and are supplied with water originating from woodland ditches, rainfall and surface runoff. This is probably the cause of significant fluctuations in the values of some water parameters, such as nitrates and pH as well as phosphates, especially at site 5 where its value reached 26 mg/dm^3 in May. The water is characterised by relatively high content of iron (Table 2).

Data collection and analysis

Samples were taken from three man-made woodland water bodies, once a month during the period from May to October 2009, using a metal frame (with dimensions of 0.25×0.25 m) digging into the bottom. A single sample represented the substrate cut from a surface of eight frames (sample area ½ m^2). All material from the frame was washed on sieves with a mesh diameter of 270 μm, then preserved in 75% ethanol and identified to the species rank (Glöer, 2002). The density of individuals per 1 m^2 was estimated.

The results of previous studies have shown the presence of numerous *H. complanatus* occurrence in water bodies located in forest complexes as well as probable preferences of individuals of this species for the substrates characterised by the presence of fallen leaves from trees (Spyra, 2010). This fact suggested a necessity for designation in each of the water bodies studied one sampling site of this type, with comparable overshadowed degree by the riparian trees.

In order to identify the optimal substrate for the occurrence of *H. complanatus*, sites with plant debris (*Phragmites australis* (Cav.) Trin. ex. Steud. and *Typha latifolia* L.) and one site with *Nuphar lutea* L. leaves (Table 1) in the third water body were selected. Numerous occurrence of *N. lutea* in pond 3 made it possible to collect samples from a sample area of ½ m^2. Due to the legal protection of *N. lutea* in Poland, snails were collected from its leaves and at the sampling site, which was done to avoid plant damage. Selection of sampling sites was also dictated by the prevalence of these types of sites in woodland water bodies. Because of this, a site with *Glyceria maxima* (Hartm.) Holmb. debris was also selected in water body 1. In general, in this research, the samples were taken from seven study sites.

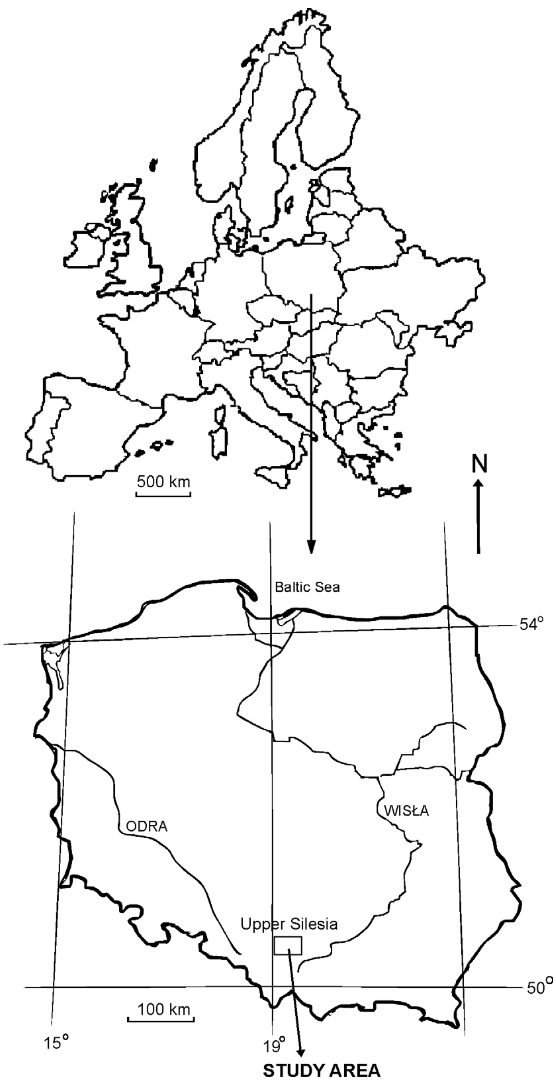

Fig. 1. Location of study area in Poland.

T a b l e 1. Characteristics of woodland water bodies studied.

Number of water body	Surface area (in ha)	Max. depth (in m)	Bottom sediment	Persistence	Number of site	Substrate from which the samples were collected	Average water depth at sampling site (in m)	Content of organic matter in bottom sediments (%)
I	23	1.8	Mud	Artificially drained*	1	*Glyceria maxima* remains	0.3	1.87–7.68
					2	Leaves fallen from trees	0.25	7.33–17.53
II	61.7	1.9	Mud	Artificially drained*	3	Leaves fallen from trees	0.33	10.69–38.21
III	11.4	3.5	Sand-mud	Permanent	4	*Phragmites australis* remains	0.42	6.33–13.55
					5	*Nuphar lutea* leaves	0.5	4.67–6.11
					6	Leaves fallen from trees	0.29	10.25–19.81
					7	*Typha latifolia* remains	0.48	12.01–17.73

* Water level regulated artificially.

Zoocenological analysis of the occurrence of snails was based on the following indices:

1. Dominance index (D) in percentage of total number of individuals in the whole collection: $D = k/K \times 100$, where k is the number of individuals of species 'a' and K the total number of individuals in a sample. The following domination classes were used (Biesiadka, Kowalik, 1980): $D > 10\%$, eudominants; $D = 5.1–10\%$, dominants; $D = 2.0–5.0$ %, subdominants; $D < 2.0\%$, recedents.
2. Frequency (F) in percentage of the number of samples: $F = n/N \times 100$, where n is the number of samples in which a given species occurs and N represents the total number of samples. The value of the frequency index (F) was divided into two classes: rare species ($F < 50\%$) and common species ($F \geq 50\%$).

Water samples were taken on each of the study sites once a month from May to October 2009. They were taken from relative to snails sample locations in order to determine the influence of selected physico-chemical water parameters on the occurrence of *Hippeutis complanatus*. Using standard methods (Hermanowicz et al., 1999), the following physico-chemical parameters were measured: temperature, conductivity, pH, content of total dissolved solids, content of NO_3^-, NO_2^-, NH_4^+, Ca, Cl, PO_4^{3+}, Fe, Mg, alkalinity and total hardness.

A sample of bottom sediments (150 ml) at each of the studied sites was collected and the organic matter content was estimated each month from May to October 2009. The sediments were dried to constant weight at 550 °C (Ostrowska et al., 1991) according to PN-88/B04481 (Myślińska, 2001). The organic matter content was determined by the loss on ignition (LOI) method, which measures weight loss in bottom sediment samples after burning at 550 °C.

Statistical analysis

Snail community data and environmental data were analysed using Canonical Correspondence Analysis (CCA) in the program CANOCO software ver. 4.5 (Ter Braak, Šmilauer, 2002). The appropriate type of analysis was chosen to analyse the species data using Detrended Correspondence Analysis (DCA) and the length of the gradient. Preliminary DCA on the species data revealed that the gradient length was more than 3 SD (3.2 SD) indicating that the species exhibited unimodal responses to underlying environmental variation which justified the use of the unimodal, direct type of analysis. Therefore, a unimodal, direct ordination CCA with a forward selection was used. The significance of the relationships between the gastropod species ordination and environmental variables, as well as the axes, was tested in the forward selection procedure using the Monte Carlo permutation test. Prior to analysis, environmental data were log transformed ln (x +1). CCA was performed using a selection in which the Monte Carlo test of significance for all variables was assessed and then only statistically significant variables were taken into account for further analysis. An ordination diagram, based on variables that statistically significantly influenced the occurrence of freshwater snails in the woodland ponds studied, was made using the program CanoDraw.

T a b l e 2. The physico-chemical parameters of water in woodland ponds studied (range of six measures at all sites except 3: five measures).

Number of water body	Number of site	Parameter													
		Temperature °C	pH	NH_4^+ mg/l	NO_2^- mg/l	NO_3^- mg/l	PO_4^{3-} mg/l	Ca mg/l	Hardness dH°	Mg mg/l	Cl mg/l	Fe mg/l	Alkalinity mg $CaCO_3$/l	Conductivity µS/cm	Total dissolved solids mg/l
I	1	6.4-21.0	6.5-7.5	0.05-0.55	0-0.02	4.8-15.0	0.01-0.2	23-32	5.3-7.0	0.6-10.9	18-28	1.54-3.07	30-95	180-450	90-200
	2	6.7-21.0	6.6-7.4	0.06-1.97	0-0.02	0.9-20.8	0.02-0.16	19-34	4.2-6.8	0.04-11.1	10.18	2.11-3.99	30-100	150-240	70-120
II	3	13.3-22.1	6.6-7.2	0.03-0.49	0.02-0.33	0.01-16.8	0.03-0.35	29-33	4.3.2007	0.2-10.3	9.17	0.77-2.76	55-80	160-200	80-100
III	4	6.1-21.3	6.2-7.4	0.03-0.64	0.01-0.05	0.5-21.7	0.01-0.52	15-23	2.01-3.9	0.01-6	8.16	0.88-3.86	31-70	70-90	30-43
	5	7.2-23.4	6.6-7.2	0.05-0.89	0.003-0.44	1.9-27.5	0.02-26.0	13-22	2.4-3.9	1.04-4.9	5.15	1.14-4.09	28-60	70-90	30-45
	6	7.0-22.9	6.6-7.1	0.07-0.4	0.01-0.07	1.4-50.0	0.01-0.16	15-22	2.1-4.8	0.01-9.9	6.12	1.04-3.92	24-55	60-84	30-54
	7	6.6-23.3	6.2-7.1	0.1-0.47	0.03-0.1	1.4.1942	0.02-0.29	14-22	2.3-5.8	0-11.8	4.18	0.96-3.92	17-50	70-112	30-94

T a b l e 3. Occurrence of Hippeutis complanatus in gastropod community in sampling sites studied.

Pond number	1				2		3							
Type of site	1. *G. maxima*		2. Leaf deposit		3. Leaf deposit		4. *P. australis*		5. *N. lutea*		6. Leaf deposit		7. *T. latifolia*	
Species	D%	F%	D%	F%	D%	F%	D%	F%	D%	F%	D%	F%	D%	F%
Galba truncatula	-	-	-	-	-	-	-	-	-	-	0.1	16.7	-	-
Stagnicola corvus	-	-	-	-	-	-	0.4	66.7	0.2	50	0.1	16.7	0.05	33.3
Lymnaea stagnalis	-	-	-	-	0.49	16.7	-	-	0.9	50	0.4	33.3	-	-
Radix balthica	0.4	16.7	0.2	16.7	0.07	16.7	0.5	83.3	0.8	50	0.1	33.3	0.3	66.7
Planorbarius corneus	2.2	100	2.1	66.7	0.5	66.7	7.3	100	6.8	83.3	3.4	100	2	83.3
Ferrissia wautieri	-	-	3.7	33.3	0.07	16.7	7.9	33.3	42.9	100	30.1	83.3	12.8	83.3
Planorbis planorbis	2	50	1.1	33.3	1.3	83.3	31.3	100	4.6	83.3	1	83.3	13.3	100
Anisus vortex	-	-	-	-	0.07	16.7	1.1	83.3	1.5	33.3	0.2	33.3	1.3	100
Bathyomphalus contortus	1.1	16.7	-	-	-	-	-	-	-	-	-	-	-	-
Gyraulus albus	0.4	33.3	2.1	50	0.2	33.3	0.3	33.3	7	66.7	7.5	100	0.3	83.3
Gyraulus crista	51	83.3	25.8	100	19.2	100	26.3	83.3	30.4	100	31.1	100	46.5	100
Hippeutis complanatus	**8.2**	**83.3**	**27**	**100**	**45.8**	**100**	**24.9**	**100**	**4.8**	**83.3**	**26**	**100**	**23.3**	**100**
Segmentina nitida	34.7	66.7	38	83.3	32.3	100	-	-	-	-	-	-	-	-
N of collected specimens	741		2276		1482		2265		1892		2469		5402	
Number of samples	6		6		6		6		6		6		6	
$\bar{X}$ density of snails (m2)	148		455		296		453		378		493		1080	

Notes: D – dominance index; F – frequency index; N – number of collected specimens.

Differences in density of *H. complanatus* at the sites studied and differences in organic matter content in bottom sediments of the freshwater habitats studied were tested with Kruskal–Wallis one-way analysis of variance ANOVA (Statistica ver. 9.0). When significant differences were indicated, the tests of multiple comparisons (post hoc) were used in order to locate statistically important differences. Only statistically significant relationships ($p < 0.05$) and differences were taken into account.

Results

H. complanatus occurrence in snail community in relation to the substratum

In woodland water bodies, 13 snail species were recorded (Table 3), ranging from 9 to 11 species in particular ponds, among which *H. complanatus* occurred numerously (3904 specimens were collected – 23.6% of total snails collected) and commonly (F = 95.5% in total material). This species belongs to eudominant species together with *Gyraulus crista* (Linnaeus, 1758), *Ferrissia wautieri* (Mirolli, 1960) and *Planorbis planorbis* (Linnaeus, 1758). It coexisted with 12 other snail species, but on each of the different types of substratum always with *Gyraulus crista*, *Radix balthica* (Linnaeus, 1758), *Planorbarius corneus* (Linnaeus, 1758), *Planorbis planorbis* and *Gyraulus albus* (O.F. Müller, 1774) (Table 3).

Regardless of the type of substratum, it belonged to common species (F > 50%). On the selected type of sites, *Hippeutis complanatus* was characterised by a different domination structure (Table 3). It occurred as eudominant on leaf deposits (sites 2, 3 and 6) where the values of its frequency index were always 100% and the average density of this species varied from 102 (water body 1) to 226 ind./m^2 (water body 2).

On various types of substrate in water body 3, *H. complanatus* occurred numerously on *Typha latifolia* remains (eudominant) (average density 419 ind./m^2) (Fig. 2) while in small numbers on leaves of *Nuphar lutea* and on *Glyceria maxima* debris (30 ind./m^2 and 20 ind./m^2, respectively). The high average density of *Hippeutis complanatus* on the *Typha latifolia* remains was associated with numerous occurrences of young individuals only during August and September, with the maximum density being reached in September (1002 ind./m^2). On the *Phragmites australis* remains, the average density was 187 ind./m^2 (Fig. 2). Differences in the average density of the different categories of substrates were statistically significant (H (4.N = 42) = 21.904, p = 0.0002). It was significantly higher on the deposits of leaves compared to *Glyceria maxima* and *Nuphar lutea* (post-hoc tests).

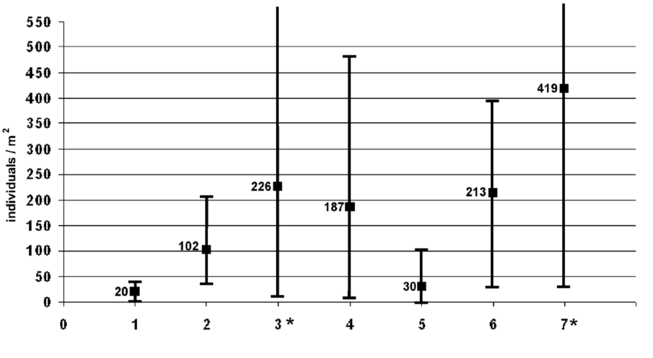

Fig. 2. The average density (ind./m^2) of *Hippeutis complanatus* for distinguished study sites.
* – Maximal density in site 3 (1006 ind./m^2), maximal density in site 7 (1002 ind./m2); Line – min. and max. density; square – $\bar{X}$. Number of sampling sites as in Table 1.

In woodland water bodies in deposits of fallen leaves from trees, *Hippeutis complanatus* consistently coexisted with three other snail species, in ponds 1 and 2 with *Gyraulus crista* and in 3 with *Planorbarius corneus* and *Gyraulus albus*.

It always coexisted with *Planorbis planorbis* on *Typha latifolia* and *Phragmites australis* remains, but on *P. australis* also with *Planorbarius corneus* and on *Typha latifolia* with *Anisus vortex*. In *Glyceria maxima*, debris always co-occurred with *Planorbarius corneus* and *Gyraulus crista* (Table 3) and on the leaves of *Nuphar lutea* always with *Gyraulus crista* and *Ferrissia wautieri*.

In each water body, and on every type of substrate, the period of the most numerous occurrence of these species was August and September (Figs 3–5), which, as was shown in previous studies, is a consequence of the reproduction of this species and the numerous juveniles appearing in this period. Their presence in September had an effect on the density achieved in comparison with other species of snails.

The decrease in density of *Hippeutis complanatus* almost always accompanied (except in September) a decrease in the density of other snails in the following months of research. The decrease in density of snails (*H. complanatus* among them) was accompanied by a decrease in the number of species each month (Figs 3–5).

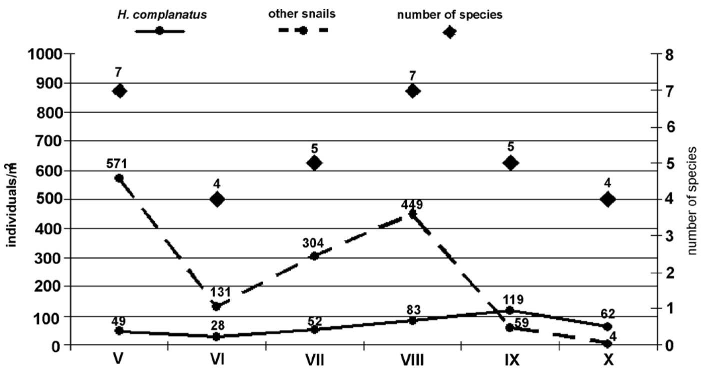

Fig. 3. Mean density of *Hippeutis complanatus* in particular months in water body 1.

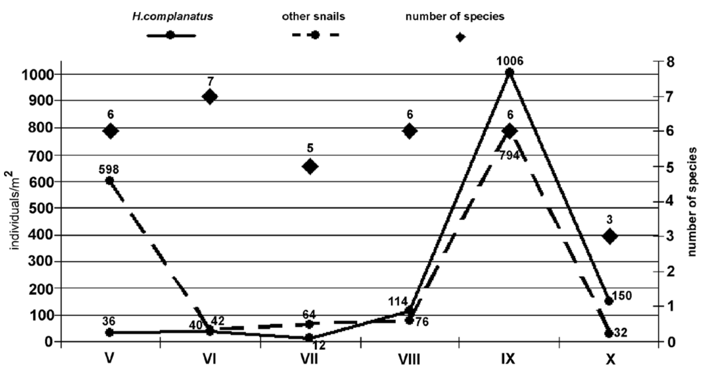

Fig. 4. Mean density of *Hippeutis complanatus* in particular months in water body 2.

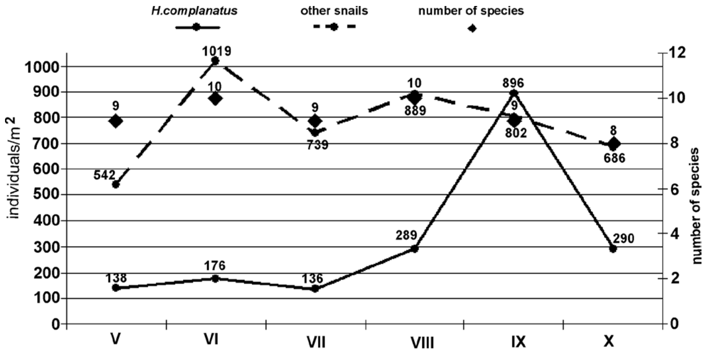

Fig. 5. Mean density of *Hippeutis complanatus* in particular months in water body 3.

CCA based on species data and environmental variables showed that the first and second axes explain almost 47% of the variance of species data, and almost 64% of the variance of species and environmental relations. The Monte Carlo test showed that these results are statistically significant (Table 4). Forward selection of environmental variables in CANOCO identified nine significant variables: leaves from trees substratum ($p < 0.05$), remains of *Phragmites australis* ($p < 0.05$) and *Typha latifolia* and also *Nuphar lutea* leaves ($p < 0.05$), content of organic matter in bottom sediments ($p<0.05$) and some of the water properties studied – pH ($p < 0.05$), NO_3 ($p < 0.05$) and Ca ($p < 0.05$) (Fig. 6). The species situated at the right side of the first axis occurred in sites which are characterised by *Phragmites australis* remains (*Stagnicola corvus, Planorbis planorbis* and *Planorbarius corneus*), *Typha latifolia* remains (*Anisus vortex* and *Gyrautus crista*) and *Nuphar lutea* leaves (*Ferrissia wautieri* and *Gyraulus albus*). *Hippeutis complanatus* were associated with sites where the bottom was covered with leaves from trees (Fig. 6).

T a b l e 4. Summary of Canonical Correspondence Analysis (CCA) carried on freshwater snail species and environmental data.

Axes	1	2	3	4	Total inertia
Eigenvalues	0.481	0.339	0.221	0.116	1.75
Species–environment correlations	0.970	0.927	0.879	0.728	
Cumulative percentage variance					
Of species data	27.5	46.9	59.5	66.1	
Of species–environment relation	37.5	63.9	81.2	90.2	
Sum of all eigenvalues					1.751
Sum of all canonical eigenvalues					1.283
Summary of Monte Carlo test					
Test of significance of first canonical axis: eigenvalues = 0.440					
F-ratio = 6.688					
P-value = 0.0020					
Test of significance of all canonical axes: Trace = 1.290					
F-ratio = 3.156					
P-value = 0.0020					

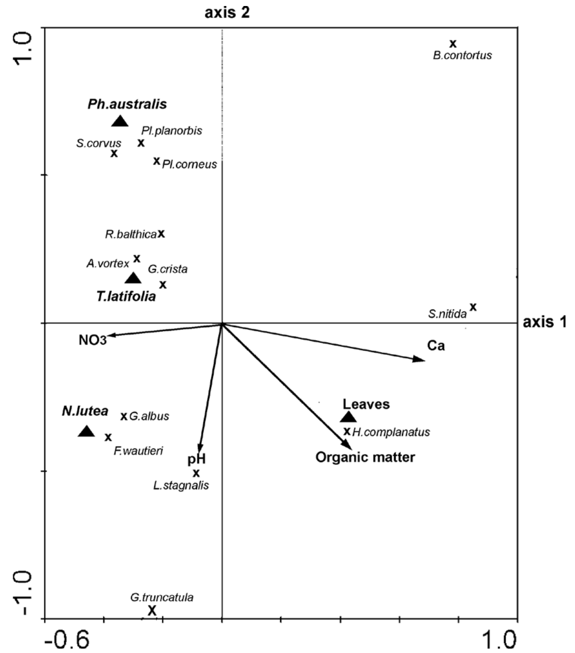

Fig. 6. Canonical Correspondence Analysis (CCA) ordination diagram based on freshwater snail species and environmental variable.

H. complanatus occurrence in relation to the organic matter

The woodland reservoirs studied are characterised by a high or very high (>10%) organic matter content in bottom sediments (Table 1). This is connected with the huge amount of allochthonous organic matter (in the form of leaves falling from trees into the water) as well as with the autochthonous matter that are produced mainly from rush vegetation, which decompose in the water. In particular ponds, the highest values were observed on sites with leaf detritus (sites 2, 3 and 6) and on site 7; the lowest value was observed on site 1 (Table 1). ANOVA showed no significant statistical differences between the organic matter content in sediments on different substrate types. The observed presence of numerous specimens of these species suggests that it prefers water bodies with a high content of organic matter in sediments. The content of organic matter varied in different months of the survey but the differences were not statistically significant. Canonical CCA showed a statistically significant association of this species and the organic matter content in bottom sediments (Fig. 6).

H. complanatus occurrence in relation to the physico-chemical water parameters

The results of study showed that *H. complanatus* occurs on a relatively wide range of the physico-chemical water properties studied. As is clear from the analysis carried out, it can tolerate a relatively high content of iron in the water. It also occurred in water bodies with a low conductivity and low water hardness (Table 2). None of the water parameters significantly statistically affected the occurrence of this species. Although *H. complanatus* is regarded as a calciphilous species, CCA has not shown a clear effect of calcium content on its occurrence (Fig. 6).

Discussion

The occurrence of freshwater snails depends on the influence of various environmental factors, for example the physical and chemical properties of water, which change with the months of the vegetation season and are specific to the aquatic environment. The type of sediment and organic matter, both autochthonous and allochthonous, covering the bottom and live plants whose presence in the aquatic environment allows snails to occur, are also significant (Lodge, 1986; Jones et al., 1999, 2000). This is particularly important in the case of woodland reservoirs in which the supply of allochthonous matter causes deposits in the form of leaves fallen from the trees. This creates a habitat of zoobenthos including freshwater snails. Irrespective of its way of origin, the organic matter takes part in the processes of decomposition in water environments and its content in the bottom sediments may be different. The quality of organic matter is an important feature with respect to the physic-chemical conditions on the bottom (Mielnik et al., 2009). This research showed that sediments in the woodland ponds are characterised by a high or very high content of organic matter, which varies in different months of the year. According to Mouthon (1992), the content of organic matter plays an important role in the distribution of snails. This may affect the presence or absence of some snail species, which in relation to *Bithynia tentaculata* and *Potamopyrgus antipodarum* (out of 27 species found in ponds) was demonstrated by Savage and Gazey (1978). Their study showed that species diversity is similarly correlated with the percentage of organic matter. The percentage of organic matter is usually associated with the abundance of macrophytes which are likely to provide food, protection and further habitat diversity. The investigations of Mouthon (1992), connected with the occurrence of molluscs, depending on the physico-chemical properties of water, bottom sediments and depths, carried out in 18 lakes, confirm the results of this study that *Hippeutis complanatus* shows preferences for environments characterised by a high content of organic matter in bottom sediments. He showed that *H. complanatus* was associated with lakes rich in organic matter which was characterised by a low content of nitrates and an increased value of the deoxidation rate, which indicates that this species tolerates periodic oxygen deficits.

It is widely believed that water temperature, pH, calcium and total hardness are among the physical and chemical parameters of water affecting the occurrence and distribution of freshwater snails (Lodge et al., 1987). They affect both the number of species and their abundance.

Calcium is an essential requirement for the successful growth and development of gastropod molluscs (Briers, 2003). Savage, Gazey (1978) in their study showed that the total number of individuals of Gastropoda and species diversity show significant positive correlation with calcium ions. Although *H. complanatus* is considered to be a calciphilous species (Young, 1975; Økland,1990; Kerne, 1999; Briers, 2003), it numerously occurred in water with relatively low calcium content (19–34 mg/l) in the water bodies studied in comparison with other types of anthropogenic reservoirs (Strzelec, 1993a; Lewin, Smoliński, 2006). This study confirms earlier results (Glöer, 2002; Spyra, 2010) that calcium content is not always a decisive factor for the occurrence this species.

H. complanatus belongs to a species found in waters with a low total hardness, according to Aho (1966) from 0.9 to 1.7 °dH. Økland (1990) showed it presence in water bodies characterised by low water hardness due to the genealogical substrate construction in which the total hardness was ≥ 0.50 °dH, but more often in waters with a hardness of ≥ 2.00 °dH. According to Young (1975) in Great Britain it was found only in places with a high value of water hardness. In this study, water reservoirs were characterised by a relatively low total hardness ranging from 2.01 to 7.0 °dH.

H. complanatus is a species that generally occurs in waters with pH > 7.4. Økland (1990) stated that it occurs at a pH from 6.1 to 9.6, in lakes at pH 7.4 and in smaller numbers at pH 6.5. In this study, the value of pH in water ranged from 6.1 to 7.5, and CCA showed no relation between the value of either the pH or other water parameters on the density of the species investigated. Perhaps this is related to the relatively high tolerance of this species to different ranges of physical and chemical parameters of water. This is supported by studies of Mouthon, Charvet (1999) that were carried out to classify the various species of freshwater snails in terms of their tolerance to biodegradable pollutions and different values of water parameters which showed that *H. complanatus* is a tolerant species, and that none of the pollutants affected its occurrence.

Freshwater snails including the Planorbid species have preference for a particular type of substrate. This may be related to the type of food consumed by different species. Tsikhon-Lukanina et al. (1998) in a study of various species of snails demonstrated the food preferences of different species, for example, *Bathyomphalus contortus* to detritus, *Gyraulus albus* and *Anisus vortex* to algae and *Planorbis planorbis* to plants. According to Lodge et al. (1987), substratum and feeding preferences influence snail assemblage among and within lakes. Snails that prefer detritus are common in woodland ponds, whereas those preferring algae are found in open ponds.

Hippeutis complanatus occurred on each of the selected types of sites, but were much more numerous on the remains of plants than on, for example, *Nuphar lutea* leaves. The dependence between the occurrence of this species and leaf debris may be connected with fact that leaf detritus is probably its food source. The increase in bacterial biomass greatly affects the quality of autochthonous and allochthonous detritus, thus allowing access to consumers from higher trophic levels (Brum, Esteves, 2001). This was confirmed by Økland (1990), who observed significantly poorer snail fauna in thinner layers of plant detritus. It is possible that food availability determines a greater abundance of *Hippeutis complanatus* at sites with leaves from trees. According to Bába (1991), plant groups can be distinguished by the characteristics of the group of molluscs in different water bodies in relation to their type of food. In his study, *H. complanatus* was a constant and dominant species only in shallow areas in two plant associations: *Scirpo-Phragmitetum* and *Glycerietum maximae*. In Norway (Økland, 1990), this species inhabits waters that have every category of vegetation, while its frequency has increased in waters with rich vegetation as compared to poor vegetation and to bogs or swamps with *Sphagnum* sp.

Hippeutis complanatus coexists with many species of freshwater snails. According to Økland (1990), it coexists with an average of four to five species in lakes, mainly with *Valvata cristata*, *Gyraulus crista*, *Acroloxus lacustris* and *Physa fontinalis*, and in small ponds with *Valvata cristata* and *Gyraulus crista.* In this study, it coexisted with 12 species (in total). In subsidence reservoirs (Lewin, Smoliński, 2006) (in total), it co-occurred with 18 species. Regardless of the type of substratum, in this study it always coexisted with Planorbid snails: *Gyraulus crista*, *Gyraulus albus*, *Planorbis planorbis* and *Planorbarius corneus* as well as with *Radix balthica*.

The lack of research conducted in woodland water bodies probably caused *Hippeutis complanatus* to be included in rare species in anthropogenic environments located in industrial areas, for example in fish ponds in Poland (Strzelec, 1993b). On the territory of Finland, *H. complanatus* is known from lakes with different trophic status, from which it was characterised by relatively high constancy of occurrence (up to 45%), although it always had a small value of the dominance index (from 0.2 to 1%) (Aho, 1966). Although in the Czech Republic this species belongs to 20 most common aquatic molluscs and it is typical in ponds (Beran, 2002) (also hypertrophic where often occurs only with *Gyraulus crista*), Beran (1999, 2007) showed the presence of this species at 18 sites in permanent stagnant waters, though only in small numbers (from 2 to 10 individuals). The data of Økland (1990) show that in Norway, this species occurs at about 80 sites. In the water bodies studied at different sampling sites from 61 to 1258 individuals were collected (in total 3598). Zeissler (1987), who found it in only 2 out of 56 surveyed waters, confirms the rarity of this species. According to Zeissler (1991), it is a rare species in woodland waters. Previous studies conducted in woodland ponds in anthropogenic areas (Spyra, 2010) showed numerous occurrences (up to 9800 specimens from allochthonous organic matter exposed to sunlight in the form of fallen leaves from trees collected during the year), which indicates the important role of water bodies located in forests as habitats of this species.

The study contributes important data about the impact of environmental conditions on the occurrence of *Hippeutis complanatus* in woodland water bodies. As a calciphilous species, it appeared numerously and frequently on sites with low calcium concentration in the water, and the study has not shown a clear statistically significant effect of physico-chemical parameters of water on its prevalence. The type of bottom substrate and organic matter content in bottom sediments determines the occurrence of this species in a more significant way as compared to the physical and chemical properties of the water. The numerous occurrences of *H. complanatus* at different kinds of substratum observed shows that it prefers water bodies with a high content of organic matter in bottom sediments. The lack of *H. complanatus* or its rare occurrence in other aquatic environments suggests that woodland ponds may be the preferred type of water bodies for the occurrence of this species. Woodland ponds can support aquatic invertebrate communities of considerable nature conservation importance (Collinson et al., 1995). This study also shows the significance of woodland ponds in the conservation of *H. complanatus* which in Poland occur in very small number. Data about the biology of snails and their relationship with different parameters can help in understanding why some species are abundant in some environments and rare in others.

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